Immediate Loading of Implants in the Edentulous Maxilla: Use of an Interim Fixed Prosthesis Followed by a Permanent Fixed Prosthesis: A 32-Month Prospective Radiological and Clinical Study

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ABSTRACT

Purpose: The aim of this study was to prospectively evaluate the survival rate of splinted and immediately loaded Straumann sandblasted, large-grit, acid-etched, solid-screw dental implants in the edentulous maxilla after 32 months of loading.

Materials and Methods: Twenty-eight patients (mean age 63 years) with edentulous maxillae received 168 implants (six each) and an implant-supported fixed interim prosthesis within 24 hours after surgery. After a mean healing time of 15 weeks, the patients received permanent screw-retained prostheses. Clinical and radiological examinations were made at implant placement and after 8, 20, and 32 months of loading. All permanent prostheses were removed at the 32-month follow-up; implant stability was checked with a torque device, and the implant stability quotient was determined with resonance frequency analysis.

Results: Mean marginal bone loss from baseline to 8 months after loading was 1.6 mm (SD 1.16; $p = .094$), from 8 to 20 months 0.41 mm (SD 0.63; $p = .094$), and from 20 to 32 months 0.08 mm (SD 0.49; $p = .039$). The 32-month cumulative survival rate was 98.2%.

Conclusions: The 32-month survival of solid-screw implants – immediately loaded within 24 hours after placement – was similar to survival rates reported for solid-screw implants with conventional loading. Immediate loading and splinting of implants in the edentulous maxilla is a viable treatment alternative.

KEY WORDS: dental prosthesis, edentulous, immediate loading, implant supported, maxilla

The Straumann Dental Implant System (Straumann AG, Basel, Switzerland) was originally designed for implant placement with a one-stage surgery technique and a non-loading healing period of 3 to 4 months – called conventional loading.[1–3] The purpose of a non-loading healing period has been to protect implants from adverse loading, which could cause micromotion in the implant and lead to fibrous encapsulation instead of successful implant osseointegration.[4] During conventional healing, the patient must wear a transitional removable prosthesis until the final implant-supported fixed prosthesis (ISFP) can be connected to the implants. Although scientific documentation on treatment outcome for conventionally loaded Straumann implants in the edentulous maxilla reports successful survival rates,[5] recent studies have shown that removable prostheses worn on implants protruding from the

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DOI 10.1111/j.1708-8208.2008.00094.x

mucosa after one-stage surgery can have traumatizing effects on peri-implant tissue and jeopardize treatment outcome.[6–8]

Several studies have reported good implant success rates when Straumann dental implants were immediately loaded after placement in the anterior mandible.[9–13] Recent studies have also demonstrated that immediate or early loading of Straumann implants in the maxilla can be a successful treatment alternative,[14–16] and that immediate implant splinting with a fixed interim prosthesis instead of a transitional removable prosthesis during healing seems to protect implants from adverse loading.[17] Shortening the time a patient must wear an interim removable prosthesis has psychological and economical advantages for the patient. But, it is generally agreed that immediate loading can be a more hazardous therapy in the maxilla than in the mandible, and that documentation and long-term follow-ups in the maxilla are lacking. For that reason, immediate loading and splinting of Straumann implants with a fixed interim prosthesis as a treatment alternative for the edentulous maxilla were investigated in this study. The same follow-up periods used in a previous study on conventionally loaded implants[6] were chosen for this study so results could be compared. The hypothesis is that implant splinting might compensate poor implant primary stability in bone tissue. Except for time of implant loading, the study protocols for this and our previous study[6] are identical. In the previous study, baseline was at 8 months after implant placement, and follow-up periods were 1 and 2 years, that is, 20 and 32 months after implant placement.

The aim of this study was to evaluate clinically and radiologically the survival rate of immediately loaded Straumann implants (loaded within 24 hours) in the edentulous maxilla after 20 and 32 months.

MATERIALS AND METHODS

Patient Selection and Pretreatment Examination

Twenty-eight consecutive patients – 13 women and 15 men with a mean age of 63 years, range 45 to 88 years (Table 1) – were included. All patients were treated in a private practice and in specialist clinics of maxillofacial surgery and prosthetic dentistry in Norrköping, Sweden, by one private practitioner, one oral surgeon, and one prosthodontist from March 2001 to March 2003. The Research Ethics Committee at the University Hospital in Linköping, Sweden, approved the study protocol. Inclusion criteria were:

TABLE 1 Age and Gender Distributions of Patients

	Age (Years)				
	40–50	51–60	61–70	71–80	81–90
Women ($n = 13$)	1	5	4	2	1
Men ($n = 15$)	2	4	4	5	0
Total ($n = 28$)	3	9	8	7	1

- An edentulous maxilla with a healing period of at least 6 months after tooth extractions;
- Sufficient bone volume for placement of six implants with a minimum diameter of 3.3 mm and a minimum length of 10 mm;
- Minimum alveolar bone width of 4 mm as judged from radiographs and clinical examination;
- A sufficient number of mandibular teeth to provide a stable occlusion (between the second premolars).

The preoperative radiographic examination included lateral radiography of the skull, panoramic and intraoral radiography, and computed tomography (two patients). Exclusion criteria were patients whose general health was poor, patients who had diseases that the investigators judged could influence the long-term follow-up, and patients with augmented bone in the maxilla. Twelve patients were smokers, six of whom smoked more than 20 cigarettes a day. The smokers were asked to refrain from smoking before surgery and during the healing period. Patients who met the inclusion criteria and gave their informed consent to participate in the study were consecutively included.

Surgical and Interim Prosthetic Procedures and Postoperative Care

One hour before surgery, patients received 2 g penicillin (Kåvepenin®, AstraZeneca, Södertälje, Sweden), 600 mg ibuprofen (Ibumetin®, Nycomed, Lidingö, Sweden), and 20 mg diazepam (Stesolid®, Dumex-Alpharma, Copenhagen, Denmark). After surgery, 2 g penicillin twice a day for 10 days was prescribed. Surgical procedures described by Buser and colleagues[18] were followed except at implant sites where the surgeon judged bone tissue to be of low density and would thus provide low implant stability. To improve primary implant stability

TABLE 2 Distribution of Jaw Shape and Bone Quality at Implant Sites ($n = 168$) According to the Index of Lekholm and Zarb[20]

	Jaw Shape					
Bone Quality	A	B	C	D	E	Total
1	0	0	0	0	0	0
2	0	12	6	0	0	18
3	0	18	84	0	0	102
4	0	12	36	0	0	48
Total	0	42	126	0	0	168

in these cases, the implant was placed so that the border between the rough and smooth surfaces was 1 to 2 mm below the level of the alveolar crest. All surgery was performed under local anesthesia comprising 2% lidocaine and 12.5 µg epinephrine (Xylocaine-Adrenaline®, AstraZeneca).

Altogether, 168 sandblasted, large-grit, acid-etched solid-screw implants (regular neck) were placed. Implant lengths of 12 or 10 mm were used. Two implants (1%) had a diameter of 4.8 mm, 133 (79%) had a diameter of 4.1 mm, and 33 (20%) were of the narrow type with a diameter of 3.3 mm. Six implants were placed in each patient according to previously used conventional protocols.[6,7,19] The implants were placed in the anterior, canine, and premolar regions. The shape and quality of the alveolar bone tissue, which were assessed during surgery according to the index described by Lekholm and Zarb,[20] were found to be predominantly of shape C and type 3 (Table 2). Seventeen patients received only implants with a diameter of 4.1 mm. Of the nine patients who received implants of two different widths, most implants in three patients had widths of 3.3 mm.

Octa or Synocta abutments (Straumann AG, Waldenburg, Switzerland) were mounted on the implants. The abutments were tightened with a torque moment of at least 10 Ncm. Directly after abutment placement, implant stability of 114 implants was assessed with resonance frequency analysis (RFA) (Osstell™, Integration Diagnostics, Göteborg, Sweden),[21–23] and the implant stability quotient (ISQ) was measured. ISQs of the first 54 implants placed could not be assessed because the manufacturer had not produced a transducer for measuring implant stability at abutment level at that time.

Octa impression caps were mounted before the mucosa was sutured. An impression was made using a maxillary removable prosthesis that had been hollowed out over the impression caps as an impression tray (Figure 1) and a polyether material (Impregum, ESPE, Seefeld, Germany). Protection caps were mounted on the abutments after impression making. The removable prosthesis that had been used before implant installation was reshaped by a dental technician into an interim, screw-retained ISFP using the impression caps as copings to retain the prosthesis.

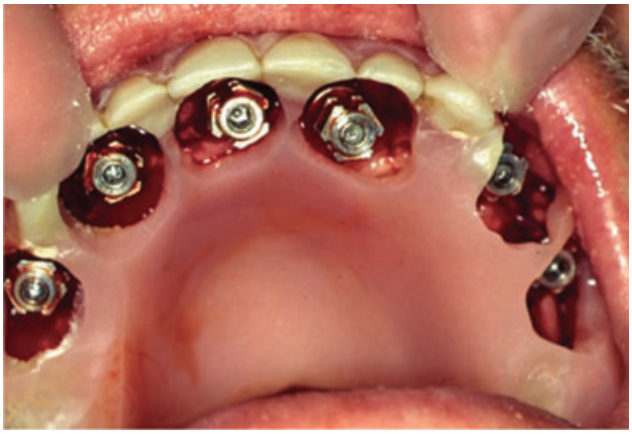

Figure 1 An impression was made using the entire removable prosthesis.

The interim fixed prostheses were made of autopolymerizing acrylic resin with no metallic reinforcement (Permadent, Forshaga Dentaldepå AB, Forshaga, Sweden). To reduce unfavorable forces, special efforts were made to minimize overjet and overbite, and ensure that the occlusal surface was flat. The interim prostheses were made without cantilevers and were delivered within 24 hours (mean time 19 hours) after implant placement and retained on the implants with occlusal screws (Figure 2).

After surgery, all patients rinsed twice a day for 10 days with an antimicrobial chlorhexidine solution

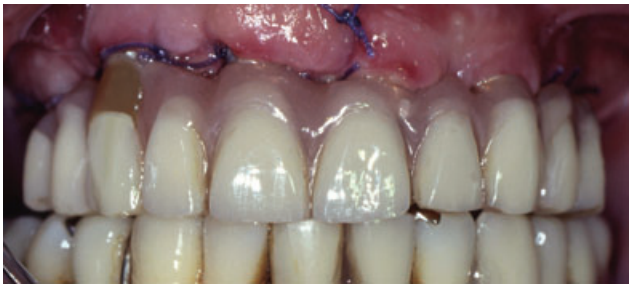

Figure 2 The interim prosthesis delivered within 24 hours after implant placement.

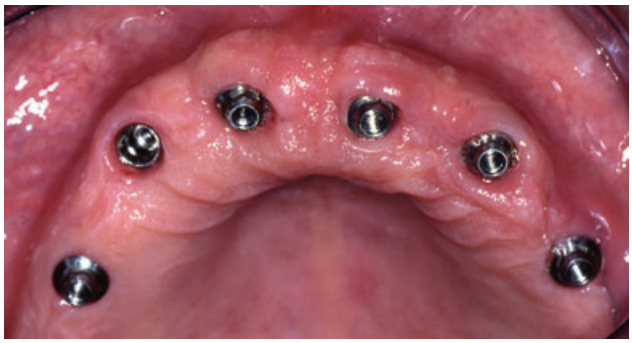

Figure 3 The mucosa and implants before impression making.

(2 mg/mL Corsodyl®, SmithKline Beecham, Brentford, UK). They were advised to follow a soft, nutritious diet (such as soups and mashed food), and to chew carefully and avoid hard or tough foods during the first 4 weeks of healing. The interim prostheses were removed after 10 to 12 days; after suture removal, they were again seated and retained. When the mucosa had healed, the patients were instructed to use interdental brushes daily with a chlorhexidine gel (1% Corsodyl).

The patients were questioned at the end of the healing period, before placement of the permanent construction:

- How many days were you on sick leave after surgery?

  Or, if retired:

- How many days did you need after surgery before you were able to undertake normal activities of daily living such as shopping, meeting with friends, and participating in club activities?

Permanent Prosthetic Procedure

The interim fixed prostheses were in use for a mean of 15 weeks (range 8 to 22 weeks). Before impression making (Figure 3), the abutments were checked with a manual torque control device that delivered a torque of 35 Ncm (according to the manufacturer's recommendations). All patients were rehabilitated with ISFPs (Figure 4). Nineteen patients received metal ceramics for esthetic reasons; nine patients received gold/acrylic resin or titanium/acrylic resin. Acrylic resin was used when the jaw relation was unfavorable for ceramic fused-to-metal or when the patient wanted to reduce costs. All ISFPs were screw retained to enable future adjustment. Occlusal contacts were evenly distributed around the arch with anterior guidance in lateral excursions and only light contact on the distal cantilevers.

Follow-Up

After about 1 month of checkups and adaptation, the ISFPs were permanently retained, and access holes to the prosthesis screws were sealed with composite resin. At this time (baseline), these clinical parameters were registered: plaque scores, bleeding index, presence of hyperplasia, visibility of the prosthesis/implant margin, occlusion, pain, and prosthesis mobility. The presence of plaque was registered according to Ainamo and Bay.[24] Bleeding as a sign of reversible plaque-induced mucosal inflammation was diagnosed as peri-implant mucositis,[25] and was determined using light pressure with a probe on the surrounding mucosa at four surfaces of each implant as described by Smedberg and colleagues.[26] Pockets were probed if signs of peri-implant mucositis were present. *Peri-implantitis* was defined as mucosal bleeding after gentle probing together with increased probing depth, occasional suppuration, and radiographic loss of crestal bone.[25] *Survival* was defined as an implant with confirmed stability in the patient's jawbone, after individual checking, with no signs of peri-implantitis, pain, or other ongoing pathologic process. *Failure* was defined as an implant with peri-implantitis or a removed implant. *Unaccounted for* was defined as an unfollowed implant.[27]

All patients, except two who died during the 8- to 20-month interval of causes unrelated to the study, were followed for 32 months after loading. At the 32-month follow-up, all prostheses were removed and implant stability was checked with a manual torque device that delivered a torque of 35 Ncm. ISQs were measured with RFA. During the follow-up period, a dental hygienist checked the patients every sixth month. Clinical registrations were made at 8, 20, and 32 months.

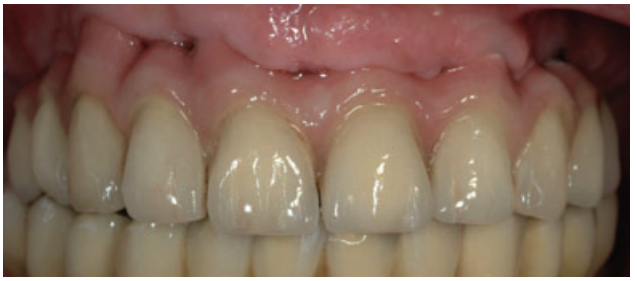

Figure 4 All patients were rehabilitated with implant-supported fixed prostheses.

Radiographic Examination and Evaluation

Intraoral radiographic examinations were made when the interim prosthesis was delivered. This time point constituted the baseline for marginal bone level measurements. Measurements were also made at the 8-, 20-, and 32-month follow-ups. Radiographs were made using a paralleling technique with a film holder (Eggen, Lillehammer, Norway). Care was taken to clearly image threads on both sides of the implant using Kodak Ektaspeed® film (Eastman, Kodak Co., Rochester, NY, USA). The film was processed in a developing processor (Dürr AC 245 L, Bietigheim-Bissingen, Germany). A specialist in oral radiology assessed the radiographs.

Marginal bone height was measured, and change in marginal bone level over time was calculated. The bone-implant interface was also inspected for signs of vertical and crater-shaped bone defects, loss of osseointegration, or any other pathologic condition. Marginal bone level was assessed from a reference point (implant shoulder) to where the bone tissue met the implant surface at the mesial and distal sides as described previously.[28] The distance was measured using a magnifying lens with a magnification factor of 7 and increments of 0.1 mm.

For 20 randomly chosen implants, measurements of marginal bone height on the mesial and distal surfaces were repeated at an interval of 1 month. The precision of a single measurement was expressed using the formula suggested by Dahlberg,[29] $s = \sqrt{\Sigma d^2/2n}$, where d is the difference between two measurements and n is the number of double measurements. Measurement precision was estimated to be 0.46 mm.

Statistical Analysis

Mean marginal bone level was calculated at baseline and at the 8-, 20-, and 32-month follow-ups. Differences between mean marginal bone levels were calculated using a paired t-test. A difference was considered significant when $p < .05$. Marginal bone level at baseline and the follow-ups and changes in marginal bone level over time associated with gender, implant diameter, smoking, and region (anterior, cuspid, and premolar) were calculated using one-way analysis of variance and Tukey's test.

RESULTS

Surgical and Prosthetic Procedure

The surgical procedure was uneventful. There was minor swelling of the mucosa and good adaptation to the interim prostheses. The mean time the patients were on sick leave or secluded from normal social activities after surgery was 1.5 days (range 0–4).

One interim fixed prosthesis fractured during the healing phase but was successfully repaired. One occlusal screw fractured in another interim fixed prosthesis. After the permanent ISFPs were fabricated, one denture tooth fractured in a definitive gold-acrylic resin ISFP before the 8-month follow-up. Between the 20- and 32-month follow-ups, three denture teeth in two titanium-acrylic ISFPs fractured. At the 32-month follow-up, one Synocta abutment was found to be fractured in one ISFP and two occlusal screws were loose in another. No complications were found in the metal–ceramic ISFPs.

Clinical Registrations

Plaque accumulation was found on 1.5% of implant surfaces at baseline and on 6.9% after 32 months. Twenty-four of the patients had no plaque at baseline. The bleeding index (possibly indicating mucositis) was 2.5% at baseline and increased to 12% after 32 months. No mucosal hyperplasia was registered at any implant surface at baseline; only four implant surfaces had mucosal hyperplasia at the 32-month follow-up. The prosthesis-implant margin (assessed as visible or non-visible) was visible at 42 implant sites (25%) at baseline and at 46 (28%) after 32 months. All ISFPs had a smooth and even occlusion.

RFA

The mean ISQ for 114 implants at implant placement was 50.6 (range 22–64; SD 6.6). After prosthesis removal at the 32-month follow-up, the mean ISQ for 159 implants was 58.2 (range 50–67; SD 3.9). This increase in mean ISQ from baseline to 32 months of loading was significant according to the paired sample test (6.98; SD 5.78; $p < .0094$).

Radiographic Evaluation

Baseline mean marginal bone level was measured at a point 1.63 mm (range 0.00 to 5.10 mm; SD 1.16) apical of the reference point. Mean marginal bone loss from baseline to 8 months was 1.6 mm (SD 1.16; $p = .094$), from 8 to 20 months 0.41 mm (SD 0.63; $p = .094$), and from 20 to 32 months 0.08 mm (SD 0.49; $p = .039$) (Figure 5). The radiographs of the study patient in Figure 6 are representative for the group.

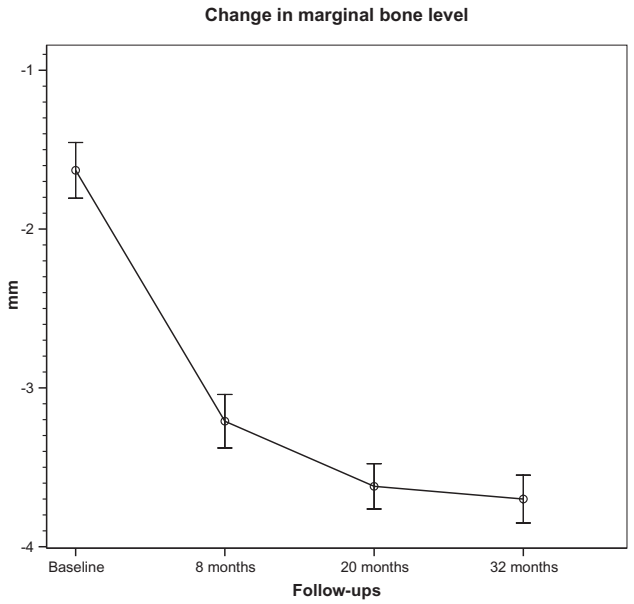

Figure 5 Change in marginal bone level from baseline to the 32-month follow-up. Mean values with 95% confidence intervals.

Table 3 illustrates changes in marginal bone level at mesial and distal implant surfaces between baseline and 32 months. Bone loss was significantly higher in women than in men between baseline and the 32-month follow-up ($p = .018$). Marginal bone loss was significantly higher at narrow implants (Ø 3.3 mm) than at standard implants (Ø 4.1 mm) between the 8- and 32-month follow-ups ($p = .034$). Mean marginal bone loss between the 20- and 32-month follow-ups was significantly more extensive around implants in the canine and anterior regions than in the premolar regions ($p = .034$) (Figure 7). Differences in mean marginal bone level between smokers and nonsmokers at the 32-month follow-up were nonsignificant ($p = .85$).

Implant Survival Rate and Complications

In total, 153 implants were followed for 32 months (Table 4). The cumulative survival rate (CSR) was 98.2%.

Three implants failed in two patients. In one patient, one implant in the premolar region was not osseointegrated after 6 weeks of healing when checked with the torque device at 35 Ncm. This implant was left in place without intervention for another 4 weeks, but was removed when osseointegration still had not occurred and clinical signs of peri-implantitis appeared. A permanent ISFP was fabricated on the remaining five

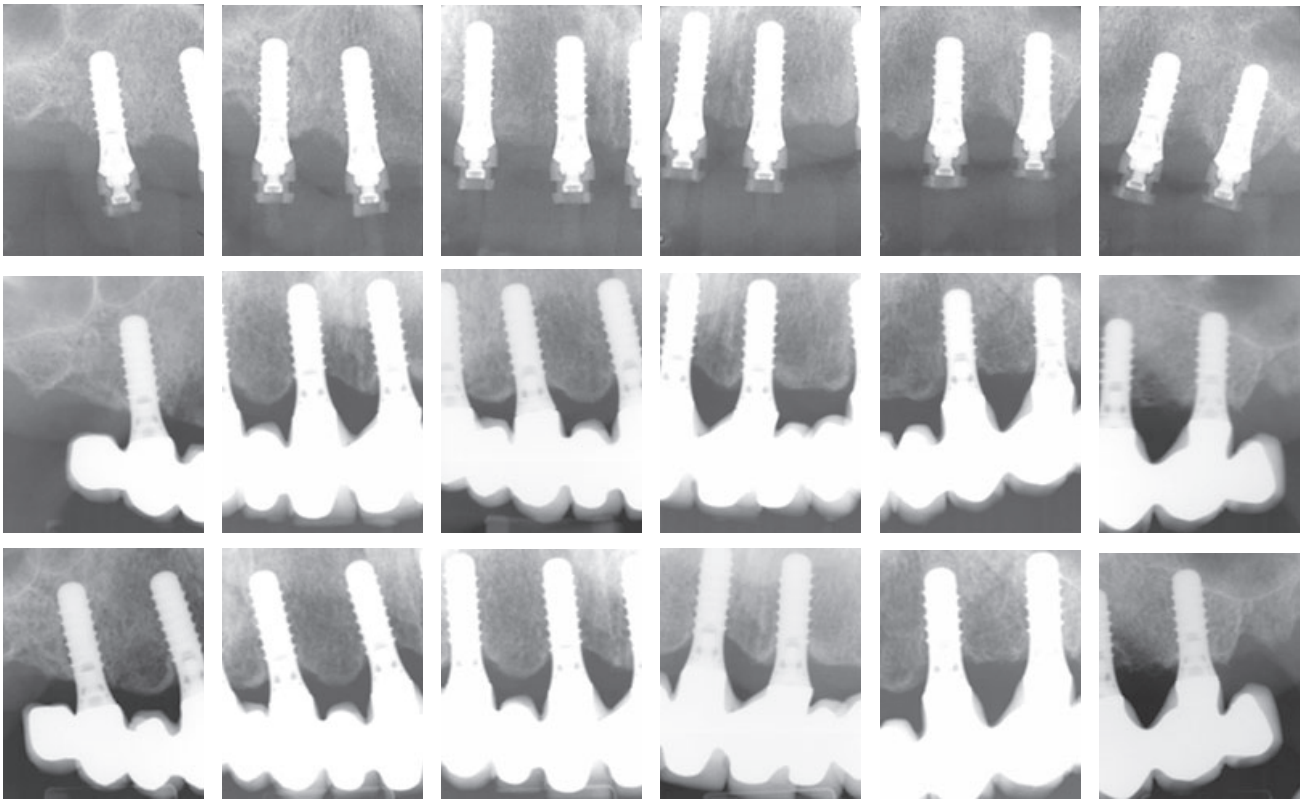

Figure 6 Radiographs from baseline with the interim prosthesis, and after 20 and 32 months with the permanent prosthesis.

TABLE 3 Changes in Marginal Bone Level at Mesial and Distal Implant Surfaces Between Baseline and 32 months, Calculated as a Percentage of Number of Surfaces Where Measurements Were Performed (*n*)

Change in Marginal Bone Level (mm)	Percentage of Implant Surfaces		
	Baseline–8 months (*n* = 319)	8–20 months (*n* = 301)	20–32 months (*n* = 303)
1.1 to 2.0	1	1	2
0.1 to 1.0	10	40	53
0.0 to (–0.9)	22	44	38
–1.0 to (–1.9)	34	10	6
–2.0 to (–2.9)	19	4	1
–3.0 to (–3.9)	10	1	0
–4.0 to (–4.9)	4	0	0
Total	100	100	100

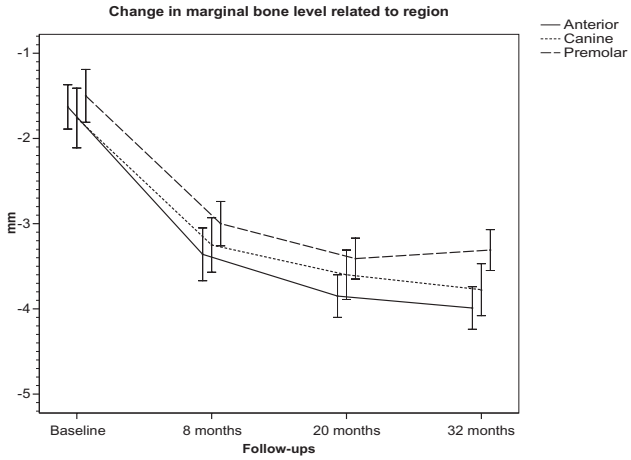

Figure 7 Change in marginal bone level related to region. Mean values with 95% confidence intervals.

implants. In a second patient, the temporary ISFP fractured after 3 weeks in the posterior region on the right side. At this time, two implants, one in the right canine region and one in the left second premolar region, were loose and showed clinical signs of peri-implantitis. They were removed, and the interim restoration was retained on the remaining four implants that showed good stability. After a prolonged healing period, two additional implants were placed. They were not connected to the interim bridge, and 22 weeks after baseline, the permanent ISFP could be connected to six successfully osseointegrated implants. The two new implants were not included in the follow-ups.

DISCUSSION

This study shows that, in a 32-month perspective, implants in the maxilla can be successfully loaded with a fixed interim prosthesis immediately after placement.

As proposed in several studies, one prerequisite for immediate implant loading is primary implant stability based on good bone quality,[11,13,30–32] which is often judged at surgery in combination with interpretation of radiographs using the bone classes proposed by Lekholm and Zarb.[20] The majority (61%) of the implants in this study were placed in type 3 bone, but nearly one-third (29%) were placed in type 4 bone (see Table 2), which is the poorest bone quality class and, according to earlier reports, could be an aggravating circumstance for osseointegration.[33,34] The primary stability of most implants placed in type 4 bone was poor, even though – in an attempt to achieve better stability – they were placed deeper in the bone tissue than were implants in other bone types. Despite this, over 98% of the implants osseointegrated successfully.

Previous studies indicated that degree of micromotion is an important factor in the achievement of osseointegration.[4,35,36] Implant motion that exceeds 50 to 150 µm is considered detrimental for osseointegration. The design of the interim acrylic

TABLE 4 Life Table Analysis

Time Period	Number of Surviving Implants	Number of Failed Implants	Unaccounted for	Survival Rate (%)	Cumulative Survival Rate (%)
Placement–8 months	168	3	0	98.2	98.2
8–20 months	165	0	12	100	98.2
20–32 months	153	0	0	100	98.2
32–44 months	153	1	0	99.3	97.5
44 months–5 years	152	0	0	100	97.5
5 years	90	0	0	100	97.5

prostheses, which in this study had a flat occlusal surface and no distal cantilevers, promoted a favorable force distribution in the prostheses and in the bone tissue surrounding the implant. A finite element analysis that compared splinted and non-splinted implants indicated that splinting of implants with an interim acrylic prosthesis can reduce strain in the bone tissue surrounding the implant by a factor of up to 9 when implants are loaded with 300 N at a 10° slope diagonally from the rear. This is most clearly seen in simulated bone tissue of lower density (lower E-modulus) compared to denser bone.[37]

Three implants were lost; two of them (in the anterior region) had been placed in type 4 bone in one patient. This patient was an unexpected heavy bruxer. The interim fixed prosthesis was fractured and two of the implants were loose and showed signs of peri-implantitis. Peri-implantitis may have been aggravated by the traumatical bite forces. In another patient, one implant in type 3 bone in the premolar region did not osseointegrate and so, after a prolonged healing period, was removed. Indications of crater-shaped bone defects but no signs of peri-implantitis were observed at five implant surfaces.

Analyses of bone level change reveal a marked resorption and remodeling of marginal bone during the first 8 months after implant placement. After 8 months, this bone activity ceases and is more or less stable between 20 and 32 months (see Figure 5). Mean marginal bone level at the 8-month follow-up in this study was 3.21 mm (range 0.40–5.85; SD 1.11) from the reference point, while baseline in our previous study[6] was 4.52 mm (range 1.45–7.70; SD 1.2) apical of the reference point. Bone level changes between 8 and 32 months in these two studies were 0.49 and 0.39 mm, respectively; the main difference in marginal bone loss occurs during the initial period of bone healing and remodeling. Women experienced significantly more bone loss compared to men between baseline and the 32-month follow-up. Women often have a narrower jaw than men, and bone quality is often poorer, perhaps because women have a higher degree of osteoporosis than men.

The mean marginal bone loss between the 20- and 32-month follow-ups was significantly more extensive around implants placed in the canine and anterior regions than around implants placed in the premolar regions (Figure 7). One explanation might be that loading forces are more vertical in the premolar region than in the anterior region, where the direction of load is more oblique and can lead to more adverse loading conditions and higher strain in the tissues surrounding the implant. Another factor could be better blood supply in the bone tissue in the posterior region with its higher degree of cancellous bone than in the denser bone tissue in the anterior region.[38]

This study's 32-month survival rate of 98.2% with immediate loading is in line with our previous study's 32-month survival rate of 96.6% with conventional loading.[6] This study's survival rate is also in line with other studies on immediate or early loading. Östman and colleagues[39] reported a 99.2% survival rate after 12 months when six to seven implants were immediately loaded with interim ISFPs. Jaffin and colleagues[14] immediately loaded six to eight Straumann implants (mainly in extraction sockets) within 48 to 72 hours after implant placement and reported a 93% survival rate. Fischer and Stenberg[16] conducted a randomized controlled trial with five to six Straumann implants that were loaded early in the maxilla, within 8 to 19 days after implant placement, and reported a 3-year CSR of 100%.

The ISQs of 114 implants were measured at implant placement with RFA. Over the course of the study, the mean ISQ increased from 50.6 (SD 6.6) at placement to 58.2 (SD 3.9) at the 32-month follow-up. Of the few studies that report stability measurements on Straumann implants, one study by Zix and colleagues[40] reported no differences in ISQ for osseointegrated maxillary implants in different bone types. Another study by Barewal and colleagues[21] reported little change in ISQ between 0 and 10 weeks after placement for implants placed in bone of good quality (type 1 or 2). But for type 4 bone, stability decreased most between placement and week 3, and increased most between weeks 3 and 10. The highly significant increase in stability in the present study ($p = .0094$) is probably because of the high percentage of types 3 and 4 bone. But, whether RFA measurements reliably predict the success of immediately loaded implants is doubtful, even though this study also found that implants with poor stability and a low ISQ could successfully osseointegrate when connected with an interim prosthesis. A more reliable predictor may be to assess whether initial ISQ is maintained or decreases, which could indicate loss of osseointegration.

The low incidence of crater-shaped bone defects in this study compared with our previous study[6] and our success with immediate loading in type 4 bone in this

study strengthen our hypothesis that immediate implant splinting compensates poor implant primary stability in bone tissue. So, our results here indicate that splinting implants immediately with a fixed interim prosthesis might protect them from unfavorable, uncontrolled loading, and improve healing conditions. But lack of controls in this study makes it difficult to estimate how much type 4 bone would influence success rates in a longer perspective.

CONCLUSION

Solid-screw implants that are immediately loaded within 24 hours of placement had a 32-month survival rate similar to rates reported for solid-screw implants that were conventionally loaded in other studies. Immediate loading and splinting of implants in the edentulous maxilla were found to be a viable treatment alternative and might improve healing conditions.

Success predictors for immediate loading of dental implants are a valuable focus for future research, as are bone quality and primary implant stability and their impact on treatment outcome.

ACKNOWLEDGMENTS

The authors thank Helena Kvist, dental technician, Boxholm, Sweden, for her excellent assistance with the interim prostheses. This study was supported by a grant from Praktikertjänst AB, Stockholm, Sweden.

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